Programming with JavaFX

Summary

1. About and History
2. Basic concepts
3. Minimal JavaFX Application
4. Application structure
5. The Scene Graph
6. Events
7. Model-View-Controller
8. The Controller in FXML
9. Properties and bindings
10. Resources
About and History

Introduction to JavaFX
GUI in Java

- Graphic framework available in Java
  - Swing
  - Extremely powerful, many extensions available
  - Complex to master, requires low-level handling
  - Hard to create visually pleasing applications

- Alternatives available
  - Most notable: SWT (Eclipse)
  - Still cumbersome to master

- On a different Universe, web-based user interfaces became nicer and faster to create
JavaFX 1.0 – forget it

- JavaFX 1 and JavaFX 2 are completely different
- Version 1 relied on a “scripting language” to describe scenes, with ‘hooks’ to activate Java code
- JavaFX 1.x is now deprecated
JavaFX 8 (and JavaFX 2.x)

- Redesigned from scratch
- The JavaFX 2.x/8.0 framework is entirely written in Java
- For visual layout, an XML file may also be used (called FXML)
- Graphic appearance borrows from web-standard CSS style sheets
- UI programming is based on easy to handle events and bindings

- Oracle plans to deprecate Swing in favor of JavaFX 2
- Now called JavaFX 8 (after Java 8 – JDK 1.8)
Getting and running JavaFX

- JavaFX is already included in Oracle JDK 7 and JDK8
  - Not in JDK 6.x
  - Not in OpenJDK (beware, Linux users!)
- JDK 8 includes significant JavaFX improvements.
- Recommended:
  - JavaFX Scene Builder (latest version: 8.1)
  - Eclipse: e(fx)clipse plugin, available in the Eclipse Marketplace
- Download links are in the course webpage
Basic concepts

Introduction to JavaFX
Key concepts in JavaFX

- **Stage**: where the application will be displayed (e.g., a Windows’ window)
- **Scene**: one container of Nodes that compose one “page” of your application
- **Node**: an element in the Scene, with a visual appearance and an interactive behavior. Nodes may be hierarchically nested

My best friend is the JavaFX JavaDoc API
http://docs.oracle.com/javase/8/javafx/api/
Some ‘Leaf’ Nodes (Controls)
Some ‘Parent’ Nodes (Container ‘Panes’)

- BorderPane (5-areas)
- Hbox, Vbox (linear sequence)
- StackPane (overlay all children)
- GridPane (row x columns)
- FlowPane (flowing boxes, wrap around)
- TilePane (flowpane with equally sized boxes)
- AnchorPane (magnetically attach nodes at corners or sides)
Some Nodes (Charts)
Nodes family

Focus on Panes and Controls
And more coming...

http://jfxtras.org/
And more coming...

http://fxexperience.com/controlsfx/

CONTROLS FX
public class Main extends Application {

    @Override
    public void start(Stage stage) {
        Group root = new Group(); // the root is Group or Pane
        Scene scene = new Scene(root, 500, 500, Color.BLACK);
        stage.setTitle("JavaFX Demo");
        stage.setScene(scene);
        stage.show();
    }

    public static void main(String[] args) {
        launch(args);
    }
}
Adding some shape

```java
public class Main extends Application {

    @Override
    public void start(Stage stage) {
        Group root = new Group();
        Scene scene = new Scene(root, 500, 500, Color.BLACK);
        stage.setTitle("JavaFX Demo");

        Rectangle rect = new Rectangle(25,25,250,250);
        r.setFill(Color.BLUE);
        root.getChildren().add(rect);

        stage.setScene(scene);
        stage.show();
    }
}
```
How to add scene content

- **In Java code**
  - By creating and adding new Node subclasses
    - Standard way, in Java (boring and error-prone)
  - By using node Builder classes
    - Programming pattern, later on…

- **In FXML**
  - By writing XML directly
  - By using the Scene Builder
  - And loading the FXML into the application
JavaFX Scene Builder 8.1

http://gluonhq.com/open-source/scene-builder/
FXML fragment

...
Building a scene from FXML

```java
public void start(Stage stage) throws Exception {
    Parent root = FXMLLoader.load(
        getClass().getResource("circle.fxml"));

    stage.setTitle("Circle Demo");
    stage.setScene(new Scene(root, 500, 150));
    stage.show();
}
```
Application structure

Introduction to JavaFX
Separation of concerns
General rules

- A JavaFX application extends javafx.application.Application
- The main() method should call Application.launch()
- The start() method is the main entry point for all JavaFX applications
  - Called with a Stage connected to the Operating System’s window
- The content of the scene is represented as a hierarchical scene graph of nodes
  - Stage is the top-level JavaFX container
  - Scene is the container for all content
public class HelloWorld extends Application {
    public static void main(String[] args) {
        launch(args);
    }

    @Override
    public void start(Stage primaryStage) {
        primaryStage.setTitle("Hello World!");

        StackPane root = new StackPane();

        Button btn = new Button();
        btn.setText("Say 'Hello World'");

        root.getChildren().add(btn);

        primaryStage.setScene(new Scene(root, 300, 250));
        primaryStage.show();
    }
}
Stage vs. Scene

`javafx.stage.Stage`

- The JavaFX Stage class is the top level JavaFX container.
- The primary Stage is constructed by the platform.
- Additional Stage objects may be constructed by the application.
- A stage can optionally have an owner Window.

`javafx.scene.Scene`

- The container for all content in a scene graph
- The application must specify the root Node for the scene graph
- Root may be Group (clips), Region, Control (resizes)
- If no initial size is specified, it will automatically compute it
Nodes

- The Scene is populated with a tree of Nodes
  - Layout components
  - UI Controls
  - Charts
  - Shapes

- Nodes have Properties
  - Visual (size, position, z-order, color, ...)
  - Contents (text, value, data sets, ...)
  - Programming (event handlers, controller)

- Nodes generate Events
  - UI events

- Nodes can be styled with CSS
Events

- FX Event (javafx.event.Event):
  - Event Source => a Node
  - Event Target
  - Event Type

- Usually generated after some user action

- You can define **event handlers** in your application
Properties

- Extension of the Java Beans convention
  - May be used also outside JavaFX
- Encapsulate properties of an object
  - Different types (string, number, object, collection, ...)
- Set/Get
- Observe changes
- Supports lazy evaluation

Each Node has a large set of Properties
**Bindings**

- Automatically connect («bind») one Property to another Property
  - Whenever the source property changes, the bound one is automatically updated
  - Multiple bindings are supported
  - Lazy evaluation is supported
  - Bindings may also involve computations (arithmetic operators, if-then-else, string concatenation, ...) that are automatically evaluated

- May be used to automate UI
- May be used to connect the Model with the View
The Scene graph

Introduction to JavaFX
Nodes

- Root node: top level container
- Intermediate nodes:
  - Containers
  - Layout managers
  - UI Composite controls
- Leaf (terminal) nodes:
  - Shapes
  - UI Controls
- Organized as a Hierarchical tree
Exploring Controls and Examples

- JavaFX Ensemble demo application
- Download from Oracle site: JavaFX Demos and Samples Downloads
- Run Ensemble.jnlp
UI Form Controls

- Controls may be combined to construct «Forms»
- Control Nodes have a **value** property
  - May be linked to application code
- Control Nodes generate **UI Events**
  - Button: ActionEvent
  - Text: ActionEvent, KeyTyped, KeyPressed, MouseClicked, ...
JavaFX 2.0 Layout Classes

- **Node** (abstract)
- **Parent** (abstract)

- **Group**
  - non-resizable

- **Region**
  - resizable & CSS styable

- **Control** (abstract)
  - resizable, skinnable, & CSS styable

- **Pane**
- **TabPane**
- **TitledBorder**
- **SplitPane**
- **Accordian**
- **ToolBar**

- **StackPane**
- **HBox**
- **VBox**
- **TilePane**
- **FlowPane**
- **AnchorPane**
- **BorderPane**
- **GridPane**
Layout Class Hierarchy

- **Group:**
  - Doesn’t perform any positioning of children.
  - To statically assemble a collection of nodes in fixed positions
  - To apply an effect or transform to that collection.

- **Region:**
  - base class for all general purpose layout panes
  - resizable and styiable via CSS
  - Supports dynamic layout by sizing and positioning children

- **Control:**
  - the base class for all skinnable controls
  - resizable and subclasses are all styiable via CSS
  - Controls delegate layout to their skins (which are Regions)
  - Each layout Control subclass provides API for adding content in the appropriate place within its skin
  - you do not add children to a control directly.
Built-in Layouts

- AnchorPane
- BorderPane
- VBox/HBox
- FlowPane
- StackPane
- TilePane
- GridPane
Built-in Layouts

- AnchorPane
- BorderPane
- VBox/HBox
- FlowPane
- StackPane
- TilePane
- GridPane
Built-in Layouts

- AnchorPane
- BorderPane
- VBox/HBox
- FlowPane
- StackPane
- TilePane
- GridPane
Built-in Layouts

- AnchorPane
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- GridPane
Built-in Layouts

- AnchorPane
- BorderPane
- VBox/HBox
- FlowPane
- StackPane
- TilePane
- GridPane
Built-in Layouts

- AnchorPane
- BorderPane
- VBox/HBox
- FlowPane
- StackPane
- **TilePane**
- GridPane
Built-in Layouts

- AnchorPane
- BorderPane
- VBox/HBox
- FlowPane
- StackPane
- TilePane
- GridPane
Creating the Scene Graph

- **The Java way**
  - Create Control Nodes
  - Set properties to new nodes
  - Add new nodes to parent node
  - With Constructors and/or with Builders

- **The FXML way**
  - Create a FXML file
  - Define Nodes and Properties in FXML
  - Load the FXML
  - (Optionally, add new nodes/properties the Java way)
Example: one text input field

```
TextField text = new TextField("Text");
text.setMaxSize(140, 20);
root.getChildren().add(text);
```

```
TextField text = TextFieldBuilder().create()
    .maxHeight(20).maxWidth(140)
    .text("Text")
    .build();

root.getChildren().add(text);
```
public class HelloDevoxx extends Application {
    public static void main(String[] args) {
        launch(args);
    }

    @Override
    public void start(Stage primaryStage) {
        primaryStage.setTitle("Hello Devoxx");
        Group root = new Group();
        Scene scene = new Scene(root, 400, 250, Color.ALICEBLUE);
        Text text = new Text();
        text.setX(105);
        text.setY(120);
        text.setFont(new Font(30));
        text.setText("Hello Devoxx");
        root.getChildren().add(text);
        primaryStage.setScene(scene);
        primaryStage.show();
    }
}
public void start(Stage primaryStage) {
    primaryStage.setTitle("Hello Devoxx");
    primaryStage.setScene(SceneBuilder.create()
        .width(400).height(250).fill(Color.ALICEBLUE)
        .root(GroupBox.builder().children(  
            TextBuilder.create()
                .x(105).y(120)
                .text("Hello Devoxx")
                .font(new Font(30)).build()
        ).build().build());

    primaryStage.show();
}
The FXML way...

- XML-based format
- Nested tree of XML Elements, corresponding to Nodes
- XML Attributes corresponding to (initial) properties of nodes

- JavaFX Scene Builder is a GUI for creating FXML files

- The FXMLLoader class reads a FXML file and creates all the Nodes
Example

```xml
<AnchorPane>
   <children>
      <VBox spacing="10.0"
         AnchorPane.bottomAnchor="0.0"
         AnchorPane.leftAnchor="0.0"
         AnchorPane.rightAnchor="0.0"
         AnchorPane.topAnchor="0.0">
         <children>
            <TextField fx:id="searchField"
               minHeight="-Infinity"
               onKeyTyped="#handleSearchBoxTyped"
               promptText="Search" />
            <HBox spacing="10.0">
               <children>
                  <ToggleButton fx:id="toggleSession"
                     selected="true"
                     text="Session"/>
                  <toggleGroup>
                     <ToggleButton fx:id="toggleSearch" />
                  </toggleGroup>
               </children>
            </HBox>
      </children>
   </children>
</AnchorPane>
```
JavaFX Scene Builder
@Override
public void start(Stage stage) throws Exception {
    Parent root = FXMLLoader.load(
        getClass().getResource("fxml_example.fxml"));

    stage.setTitle("FXML Welcome");
    stage.setScene(new Scene(root, 300, 275));
    stage.show();
}
Linking FXML and Java

- FXML element may have an associated attribute `fx:id`
- Nodes may be later retrieved by
  - `public Node lookup(java.lang.String selector)`
  - Finds a node with a specified ID in the current sub-tree
  - Example:
    - `scene.lookup("#myId");`
- Node references can also be «injected» using the `@FXML` annotation (see later)
Events

Introduction to JavaFX
Interacting with Nodes

- In JavaFX applications, events are **notifications** that something has happened.
  - An event represents an occurrence of something of interest to the application
  - As a user clicks a button, presses a key, moves a mouse, or performs other actions, events are dispatched.
- Registered event filters and **event handlers** within the application
  - **receive** the event and
  - **provide** a response.
What is an event?

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Event type</td>
<td>Type of event that occurred.</td>
</tr>
<tr>
<td>Source</td>
<td>Origin of the event, with respect to the location of the event in the event dispatch chain. The source changes as the event is passed along the chain.</td>
</tr>
<tr>
<td>Target</td>
<td>Node on which the action occurred and the end node in the event dispatch chain. The target does not change, however if an event filter consumes the event during the event capturing phase, the target will not receive the event.</td>
</tr>
</tbody>
</table>

Event types:
- KeyEvent.KEY_PRESSED
- KeyEvent.KEY_RELEASED
- KeyEvent.KEY_TYPED
- ActionEvent.ACTION
- MouseEvent.MOUSE_PRESSED
- MouseEvent.MOUSE_RELEASED
- WindowEvent.WINDOW_SHOWING
- WindowEvent.WINDOW_SHOWN

...
Event propagation

- Events are generated on the source node
- Events propagated in the scene graph hierarchy («dispatch chain»), in two phases
  - **Dispatching**: downwards, from root to source node
    - Processes Event Filters registered in the nodes
  - **Bubbling**: upwards, from source node to root
    - Processes Event Handlers registered in the nodes
- If you want an application to be notified when an event occurs, register a filter or a handler for the event
- Handlers may “consume” the event
Event Handlers

- Implements the `EventHandler` interface
- Executed during the event bubbling phase.
- If does not consume the event, it is propagated to the parent.
- A node can register more than one handler.
- Handlers for a specific event type are executed before handlers for generic event types.
  - For example, a handler for the `KeyEvent.KEY_TYPED` event is called before the handler for the `InputEvent.ANY` event.
- To consume an event, call the `consume()` method
Registering Event Handlers

- `setOnEvent-type(EventHandler<? super event-class> value)`
  - **Event-Type**
    - The type of event that the handler processes (e.g. `setOnKeyTyped`, `setOnMouseClicked`, ...)
  - **Event-class**
    - The class that defines the event type (e.g., `KeyEvent`, `MouseEvent`, ...)
  - **Value**
    - The event handler for event-class (or for one of its super classes)
      - Must implement: `public void handle(ActionEvent event)`
      - May be a regular class or an anonymous inline class
Example

class ButtonActionHandler implements javafx.event.EventHandler<ActionEvent> {

    public ButtonActionHandler (/*params*/) {
        // constructor - if needed
    }

    @Override
    public void handle(ActionEvent event) {
        Button b = (Button)event.getSource();
        //...do something
        String buttonText = b.getText();
        // ...
    }
}

Button btn = new Button();
btn.setOnAction(new ButtonActionHandler());
Example (inline definition)

Registration & Anonymous event handler

```
btn.setOnAction(new EventHandler<ActionEvent>() {
    public void handle(ActionEvent event) {
        System.out.println("Hello World");
    }
});
```
Model-View-Controller

JavaFX programming
Application complexity and MVC

- Interactive, graphical applications exhibit complex interaction patterns
- Flow of control is in the hand of the user
- Actions are mainly asynchronous

- How to organize the program?
- Where to store data?
- How to decouple application logic from interface details?
- How to keep in sync the inner data with the visible interface?
Media Player example

The model contains all the state, data, and application logic needed to maintain and play mp3s.

```java
class Player {
  play()
  rip()
  burn()
}
```

The view displays information to you.

You see the song display update and hear the new song playing.

“Play new song”

You use the interface and your actions go to the controller.

The model notifies the view of a change in state.

Controller asks Player model to begin playing song.

Controller manipulates the model.

Model tells the view the state has changed.
MVC pattern defined

**CONTROLLER**
Takes user input and figures out what it means to the model.

**VIEW**
Gives you a presentation of the model. The view usually gets the state and data it needs to display directly from the model.

**MODEL**
The model holds all the data, state and application logic. The model is oblivious to the view and controller, although it provides an interface to manipulate and retrieve its state and it can send notifications of state changes to observers.

1. The user did something
2. Change your state
3. Change your display
4. I've changed!
5. I need your state information

Here's the model; it handles all application data and logic.

Here's the creamy controller; it lives in the middle.

This is the user interface.
Normal life-cycle of interaction

1. You're the user — you interact with the view.
The view is your window to the model. When you do something to the view (like click the Play button) then the view tells the controller what you did. It's the controller's job to handle that.

2. The controller asks the model to change its state.
The controller takes your actions and interprets them. If you click on a button, it's the controller's job to figure out what that means and how the model should be manipulated based on that action.

3. The controller may also ask the view to change.
When the controller receives an action from the view, it may need to tell the view to change as a result. For example, the controller could enable or disable certain buttons or menu items in the interface.

4. The model notifies the view when its state has changed.
When something changes in the model, based either on some action you took (like clicking a button) or some other internal change (like the next song in the playlist has started), the model notifies the view that its state has changed.

5. The view asks the model for state.
The view gets the state it displays directly from the model. For instance, when the model notifies the view that a new song has started playing, the view requests the song name from the model and displays it. The view might also ask the model for state as the result of the controller requesting some change in the view.
Mapping concepts to JavaFX

- **View:** presenting the UI
  - FXML
  - The Nodes in the Scene Graph
- **Controller:** reacting to user actions
  - Set of event handlers
- **Model:** handling the data
  - Class(es) including data
  - Persistent data in Data Bases
Design Exercise

- Imagine an application managing a list of items (e.g., names)
- Different items in the user interface should manage the same set of data, with different criteria and actions
  
  - Where do you declare the data class?
  - Which class should have access to which?
  - Who creates what objects?
A possible solution
The Controller in FXML

JavaFX programming
The Controller in FXML

- Several attributes in FXML help in the definition of the Controller behavior associated to a scene
  - Identification of the Controller class
  - Injection of Node identifiers (references)
  - Registration of event handlers
- Additionally, the JavaFX Scene Builder may generate a «controller skeleton» for inclusion in the project
Defining the Controller class

- The Root element of the scene graph may specify a `fx:controller` attribute

```xml
<BorderPane id="BorderPane" xmlns:fx="http://javafx.com/fxml" fx:controller="it.polito.tecnprogr.RuzzleController"/>
```
fx:controller attribute

- Associate a "controller" class with an FXML document
  - Automatically create the instance when FXML is loaded
- Should include event handler methods
- May include an initialize() method
  - public void initialize();
  - called once when the contents of its associated document have been completely loaded
  - any necessary post-processing on the content
Accessing the controller instance

- The Application often needs to communicate with the controller object
  - E.g., to call setModel()
- FXMLLoader provides this information

```
URL location = getClass().getResource("example.fxml");
FXMLLoader fxmlLoader = new FXMLLoader(location);
Pane root = (Pane)fxmlLoader.load();
MyController controller = (MyController)fxmlLoader.getController();
```
Injection of Node references

- The controller code may directly access various Nodes in the associated scene graph.
- The attribute @FXML associates a Node variable with the corresponding node, with the same fx:id value as the variable name.
  - No more error-prone «lookup» calls...
  - Local variables in the controller instance.
- Try: View | Show Sample Controller Skeleton on the Scene Builder!

```
@FXML // fx:id="theTitle"
private Label theTitle;
```
Registration of Event Handlers

- In FXML, you may set a event handler through attributes
  - `onAction`, `onKeyTyped`, `onMouseClicked`, ... hundreds more ...
- The value should be the `#name` of a method in the controller class
  - With the right signature for the event type

```xml
<Button fx:id="cercaBtn" onAction="#doCercaParola" text="Cerca" />
```

```java
@FXML
void doCercaParola (ActionEvent event) {
```
Resources

Introduction to JavaFX
Resources

- **Official**

- **Documents**
  - [http://docs.oracle.com/javafx/](http://docs.oracle.com/javafx/)
  - [http://docs.oracle.com/javafx/2/api/index.html](http://docs.oracle.com/javafx/2/api/index.html)

- **Blogs**
  - [http://fxexperience.com/](http://fxexperience.com/)
  - [http://community.java.net/community/javafx](http://community.java.net/community/javafx)
Resources

- **API**
  - [http://docs.oracle.com/javafx/2/api/index.html](http://docs.oracle.com/javafx/2/api/index.html)

- **Slides/Tips**
  - [http://www.slideshare.net/steveonjava/java-fx-20-a-developers-guide](http://www.slideshare.net/steveonjava/java-fx-20-a-developers-guide)

- **Tutorials/Articles**
  - [http://docs.oracle.com/javafx/2/events/jfxpub-events.htm](http://docs.oracle.com/javafx/2/events/jfxpub-events.htm)

- **Examples (Downloads)**
Resources

- **FXML Controller**

- **Charts**
  - Using JavaFX Charts tutorial: [http://docs.oracle.com/javafx/2/charts/jfxpub-charts.htm](http://docs.oracle.com/javafx/2/charts/jfxpub-charts.htm)

- **Books**
  - Head First Design Patterns, chapter 12
Resources

- Properties and Bindings
  - [http://docs.oracle.com/javafx/2/binding/jfxpub-binding.htm](http://docs.oracle.com/javafx/2/binding/jfxpub-binding.htm)
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